WATER QUALITY

A number of organizations currently take water quality samples throughout the ACEC (Figure 11). Some of these sampling stations have been used in comprehensive regional water quality studies including the DMF Monograph Series (Jerome 1968, Chesmore 1973), DEP water quality surveys (1989), DMF Sanitation Surveys (Roach 1992), the Plum Island Sound Minibay Project (Buchsbaum et al. 1996), and the Plum Island Sound Comparative Ecosystem Study (PISCES) (Woods Hole MBL 1997). Flushing characteristics, temperature, salinity, dissolved oxygen, and fecal coliform parameters were commonly sampled in these water quality studies. In the older DMF monographs (Jerome 1968, Chesmore 1973), pesticide analysis was also done because of the historic widespread use of DDT (modern reports do not contain this information as the use of DDT has been banned). Results from portions of both Plum Island Sound and Essex Bay water quality studies are summarized below.

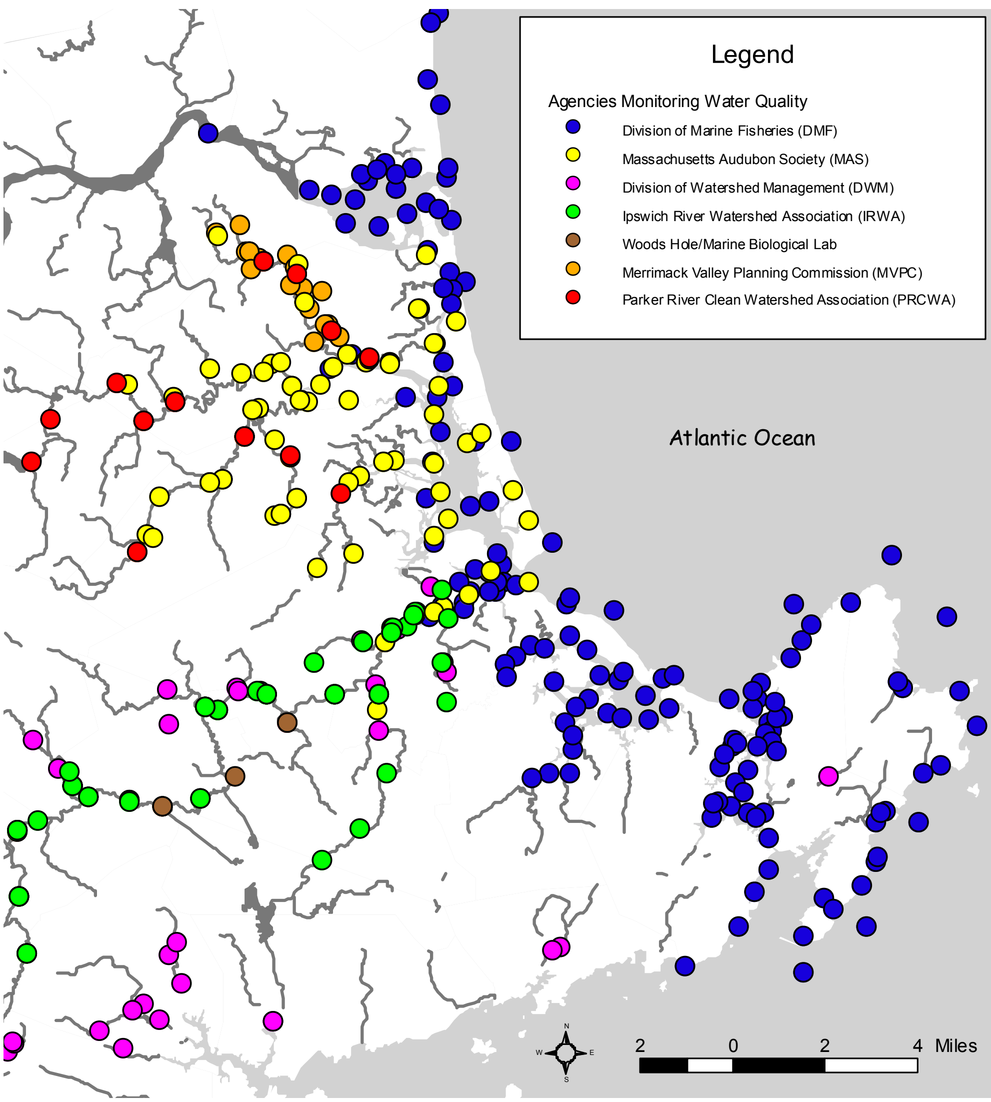

Figure 11. Water quality sampling sites and contacts

PLUM ISLAND SOUND

Physical and Chemical Results

The following physical and chemical factors were evaluated in this inventory: flushing time, dissolved oxygen, salinity, nutrients, and toxic contaminants.

Flushing time. Flushing is a measure of the speed at which a drop of water enters and leaves a certain segment of a water body. Flushing is an important consideration in water pollution studies because it determines how long a given pollutant remains within an area. Dry weather flushing times in the lower part of Plum Island Sound are one day or less. This means that there is a rapid turnover of water and any pollutant entering from the rivers is rapidly flushed out to the ocean through the Sound. In contrast, the longest flushing times were in the upper parts of the Sound where water entering from the Parker and Rowley Rivers remains for over nine days (Massachusetts Audubon Society 1999).

Dissolved oxygen. The 1968 and 1992 DMF surveys and the 1996 Minibay results indicated that Plum Island Sound does not have a low dissolved oxygen (DO) problem. However, both the 1996 Minibay project and 1989 DEP survey found that dissolved oxygen levels in some of the upstream monitoring stations were occasionally below the state standard of 6.0 ppm. This indicates that tributaries have a potential problem of organic matter input and nutrient loading (DEP 1989, Buchsbaum and Purinton 2000).

Salinity. Salinity surveys in 1992 and 1993 ranged from 0.22 - 30.4 ppt in the Parker River stations and from 22.3 - 30.8 ppt in the Plum Island Sound stations (Buchsbaum and Purinton 2000).

Nutrients. Suspended solids for Ipswich River and Bay were sampled as part of the 1989 DEP Division of Water Pollution Control water quality survey. Results indicate that suspended solids in the river main stem and open water stations were lower than readings from the tributaries. The 1989 DEP survey of the Ipswich River found that nutrient levels were highest at tributary rather than open-water stations where nutrient values were lower as a result of dilution. This survey identified hot spots of high nitrogen and phosphorus levels located at Greenwood Creek below the Ipswich wastewater treatment plant outfall (DEP 1989, 1990). Although the treatment plant, (which had several upgrades in recent years) could be one source of high nutrient levels, other causes might be from nearby failing septic systems or slow pollutant flushing times in Greenwood Creek (Roach per comm 2000).

Phosphate, silicate, total nitrogen, total phosphorus, and chlorophyll α were sampled as part of the Minibay study in 1992 and 1993. Nutrient analyses indicate a range of values varying over seasons and among different sample stations. Because the results vary so much, "…it is difficult to make generalizations. Phosphate, for instance, appears to have a pattern of increasing upstream concentrations in June and August, but less obviously so or not at all during the other three surveys. Silicate routinely shows increasing upstream concentrations, most obviously for the Parker River. Nitrate plus nitrite, and to a lesser degree ammonia, show similar patterns to silicate, but are less consistent" (Buchsbaum et al. 1996). *(For detailed nutrient sampling results in Plum Island Sound, see the 1996 Minibay report*).

Toxic contaminants. Landfills, private industries, marinas, junkyards, and underground storage tanks are located in ACEC towns. Although the source of most contamination from metals, inorganics, volatile organic compounds, and total dissolved solids is known, the degree of pollution from these sources is not well documented (Buchsbaum et al. 1996). Of the landfills located in Ipswich, Rowley, Newbury, and Newburyport, only two have pollutant monitoring data. Both Newbury and Rowley's landfills are adjacent to salt marsh habitats within the ACEC (Buchsbaum et al. 1996). Test results from the Rowley landfill (which opened in the 1950s and closed in 1992) indicate low levels of toxins. The engineering firm that prepared the report determined that, "…the levels were not of concern and future analysis was deemed unnecessary" (Buchsbaum 1996). As a result of high levels of contaminants found at the Newbury landfill, DEP has been keeping close watch on the environmental impacts (Mountain per comm 2000).

Industrial contamination is mostly a concern in the Parker Watershed where the Lord Timothy Dexter Industrial Park in Newburyport is located along the Little River. Sediment tests performed by the Parker River Basin Team in 1994 indicate that metal concentrations were below levels determined to cause significant detrimental impacts to biota even though high levels of arsenic and aluminum were found (Buchsbaum and Purinton 2000). In the Ipswich River, a DEP study of water quality found high levels of zinc from samples collected near the public boat ramp (DEP 1989, 1990).

Microbial Contamination

Fecal coliform bacteria are common indicators that disease-causing bacteria and viruses from human and/or animal wastes are likely to be in the water. Generally, downstream and open water sampling sites in Plum Island Sound show lower bacteria counts than upstream sites as a result of dilution and mortality as distances from land-based sources increase (DEP 1989, 1990). Between 1992 and 1995, the Minibay study collected and tested more than 600 water samples from 42 stations in Plum Island Sound and its tributaries. This data was used to determine hot spots of unusually high fecal coliform concentrations in the region and to identify rivers and streams that contribute high bacterial loading to the Sound. Study results are summarized for five areas: Plum Island Sound, Ipswich River, Parker River, Rowley River, and Parker River National Wildlife Refuge. The following section (except for italicized text) summarizing fecal coliform results is taken directly from *Conserving the Plum Island Sound/River Ecosystems* report (Massachusetts Audubon Society, 1999).

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Plum Island Sound and Plum Island River

Plum Island Sound itself is characterized by low concentrations of fecal coliform bacteria during dry weather. The state standard for shellfishing, which is a geometric mean of 14 colony forming units (cfu) per 100 ml, was met at all stations in the Sound itself when the weather was dry. During rain events, however, a number of stations exceeded 14 cfu/100 ml, which supports the current designation of the Sound as conditionally approved depending on rainfall.

Table 12. Fecal coliform concentrations in Plum Island Sound and Plum Island River Stations					
Station Location	Station Type	# of Samples Dry	# of Samples Wet	E coli/100ml Dry	E coli/100ml Wet
Off Castle Hill	boat	7	2	3	38
Off Helicat Swamp	boat	7	2	5	13
Eagle Hill River	boat	7	2	9	24
Rowley River Mouth	boat	3	1	2	8
Plum Island River at Jericho Creek	boat	6	2	10	12
Pine Island Creek	shore	4	3	15	51

Ipswich River Segment
Water flowing over the Sylvania Dam is relatively clean, but then a jump in fecal coliform concentrations occurs as the river passes through the center of Ipswich between the dam and the town landing. Bacterial concentrations remain high throughout the estuary but are gradually diluted closer to the mouth of Ipswich Bay (*note: since the 1996 Minibay study, DMF has detected fecal coliform concentrations increasing in dry weather from the Ipswich Town Landing to the mouth of the Ipswich River. At this time, a cause for these trends is not well understood*). High concentrations of fecal coliforms also occur in three tributaries of the Ipswich River, particularly Kimball Brook. *See the Ipswich Coastal Pollution Control Committee Report (1995) for additional information.*

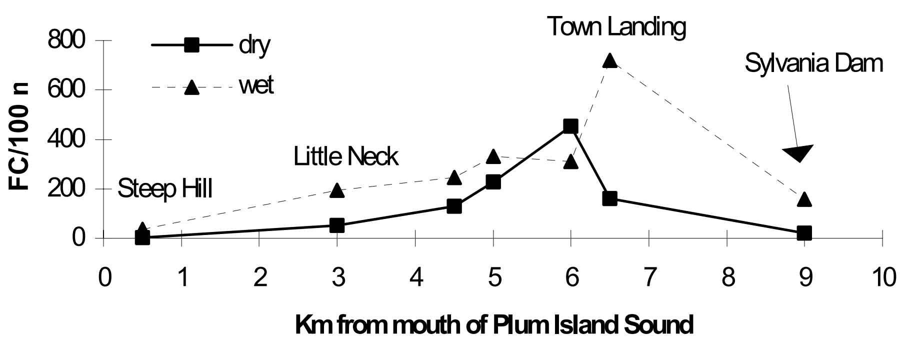

Figure 12. Gradients of Fecal Coliform – Ipswich River Main stem

Rowley River Segment
The main stem of the Rowley River averaged less than 25 fecal coliform concentrations per 100 ml during dry weather, slightly above the allowable levels for shellfishing. The increase in fecal coliform contamination throughout the Rowley River after heavy rainfalls suggests that there are inputs of contaminated stormwater, particularly in the area just downstream from the town landing.

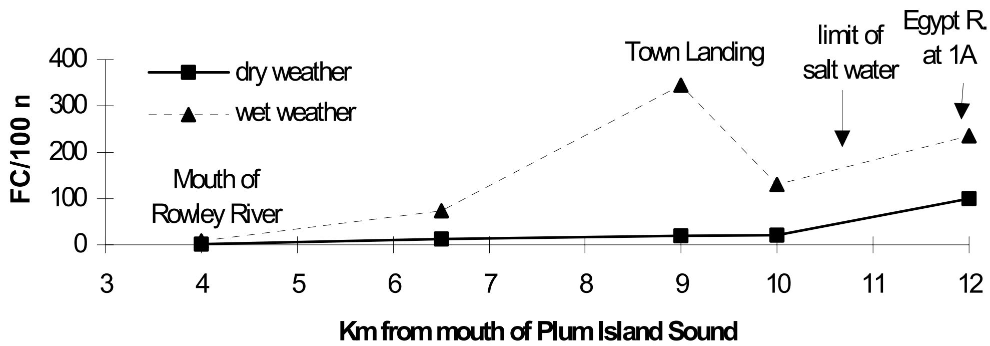

Figure 13. Gradients of Fecal Coliform – Rowley River Segment

Parker River Segment

The main stem of the Parker River is relatively clean when it passes over the dam in Byfield. Within the estuarine part of the Parker, however, there is a slight increase in bacteria from as yet undiscovered sources. This is then gradually diluted before the Parker River flows into Plum Island Sound. Hot spots for fecal coliforms within the Parker River segment include a small creek near the Governor Dummer Academy, Ox Pasture Brook in the center of Rowley, and the Little River, particularly at Hanover Street.

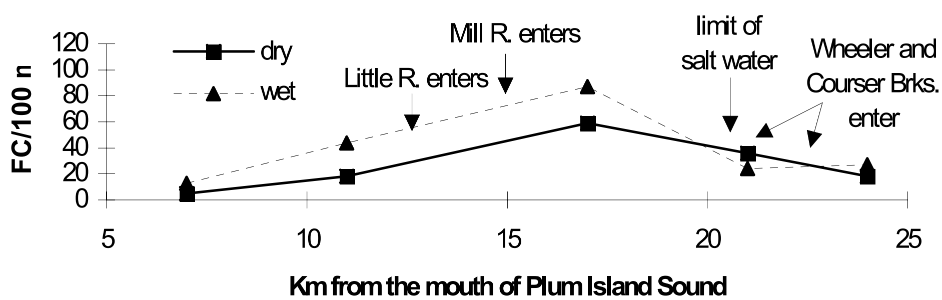

Figure 14. Gradients of Fecal Coliform - Parker River Segment

Relative Loadings to the Sound from Different Segments

Over 70 percent of the fecal coliforms entering Plum Island Sound during dry weather and 52 percent during wet weather originate from the center of Ipswich between the Sylvania Dam and the town wharf. Despite this relatively large load, it is highly unlikely that the Ipswich River has a significant impact on water quality in the central and northern parts of the Sound, where many clam flats are located because water from the Ipswich River is rapidly flushed out into Ipswich Bay. Nonetheless, about one-quarter of the potential clam flats in the Plum Island Sound region are located in the Ipswich River estuary itself, and these are closed due to the contamination entering the river downstream from the Sylvania Dam.

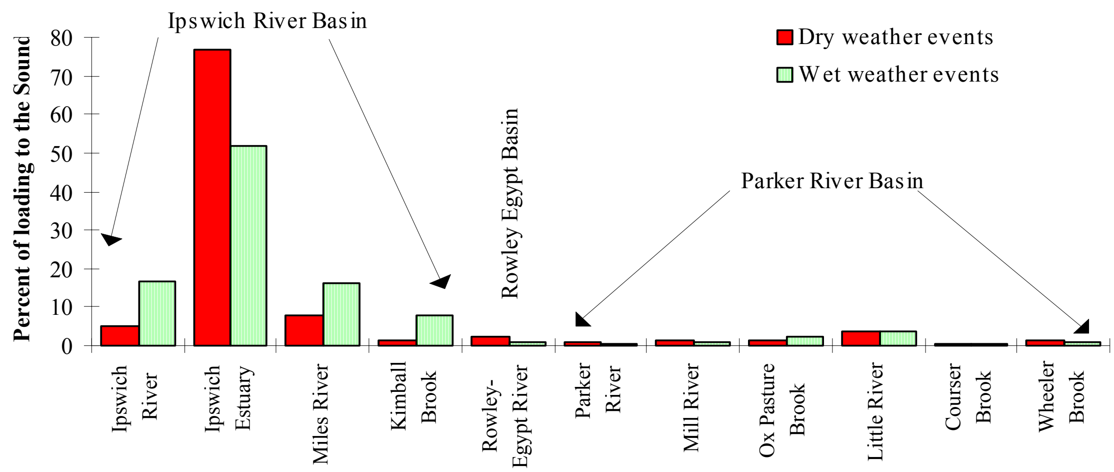

Figure 15. Relative Loadings of Fecal Coliform to Plum Island Sound from All Basins

Bacteria from the Parker River affect the central and northern sections of the Sound. The Little River in Newbury is the largest source of bacteria to the Parker River estuary (about 40 percent in both dry and wet weather). The Rowley River and the Parker River National Wildlife Refuge do not contribute significantly to fecal coliform loadings in Plum Island Sound.

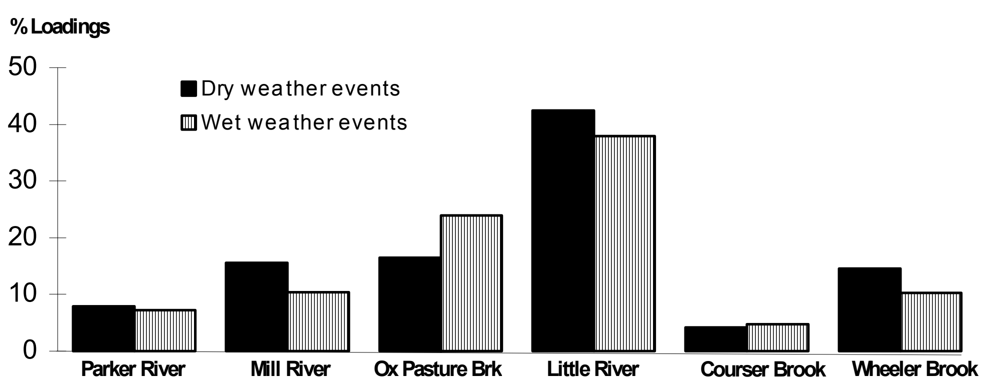

Figure 16. Relative Loadings of Fecal Coliform to Plum Island Sound: Parker River Basin

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Pollution Sources in Plum Island Sound

To determine sources of pollution, shoreline surveys were conducted throughout Plum Island Sound as part of the 1996 Minibay project. Sources such as drainage ditches, discharge pipes, faulty septic systems, outfall from sewage treatment facilities, and agricultural runoff were documented as part of this study (Buchsbaum et al. 1996). Because multiple sources of potential pollution were identified in each segment of the watershed surveyed, it is difficult to attribute cause to any one source of pollution. "One exception is the wastewater treatment plant for Governor Dummer Academy located in the Mill River where consistently high levels of fecal coliform contamination were identified through water quality sampling" (Buchsbaum et al. 1996). Although Governor Dummer upgraded their treatment system five years ago, studies show that their collection system is inadequate. Other sources identified that warrant further investigation are shown in Table 13.

Table 13. Potential sources of pollution in the Plum Island Sound region (Massachusetts Audubon Society 1999)

Source Type	Location
Wastewater treatment facilities and other point sources	Ipswich River estuary
	Mill River (Rowley)
Urban stormwater runoff	Ipswich River
Faulty or inadequate septic systems or illegal hookups	Little River (Newbury, Newburyport)
	Ox Pasture Brook (Rowley)
	Ipswich River estuary
	Kimball Brook
	Farley Brook
Agricultural, including horses	Miles River (Ipswich)
	Little River (Newbury)
	Mill River (Rowley)
Feral Waterfowl	Ipswich River Estuary
	Ox Pasture Brook

ESSEX BAY

A water quality survey in tidal portions of Essex Bay and rivers was performed by DEP's Division of Water Pollution Control during the summer of 1989. Samples were collected at 48 stations for assessment of water quality, sediment quality, and selected biological parameters. Physical and chemical parameters sampled at open water stations include depth, dissolved oxygen, salinity, temperature, and specific conductivity. Biological parameters sampled include phytoplankton and chlorophyll, bacteria, macroalgae, and mussel tissue (DEP 1989, 1990, Roach 1992).

Physical and Chemical Results

Flushing time. Essex Bay is a tidally dominated estuary where contaminants are quickly dispersed bay wide in as little time as ½ a tidal cycle (Roach 1992).

Dissolved oxygen. Dissolved oxygen (DO) concentrations measured at Essex River tributary and town stations were generally lower than concentrations found farther downstream or in open water. DO concentrations dropped below the state water quality standard of 6.0 ppm in seven of the Essex sampling stations. As in Plum Island Sound, “the reason for depressed oxygen values is unknown, but suggests that upstream sources may be imposing an oxygen demand” (DEP 1989, 1990).

Salinity. Salinity surveys ranged from 13 - 30.3 ppt in the main stem of the Essex River, Castle River, and bay stations, from 0.5 - 30.1 ppt in the tributary stations, and from 20.5 – 32.0 ppt in Bay stations (DEP 1989, 1990).

Turbidity. Suspended solids and turbidity were generally higher in tributary stations which suggests that runoff and erosion or sediment resuspension may be occurring in these areas. Consistently elevated suspended solids and turbidity were especially high in an unnamed creek that flows into the Essex River near the public boat ramp in Essex town center.

Nutrients. Total nitrogen concentrations were also generally higher in tributary samples with values ranging from < 0.90 mg/l in the main stem river and open water stations. Nitrate concentrations in Essex Bay were usually low throughout the survey period. Similarly, open water stations tended to exhibit lower ammonia concentrations than the tributary and upriver stations. “This pattern indicates that pollutants are being diluted as they flow further from their land-base sources through the estuary and out into open waters” (DEP 1989, 1990). Phosphorus concentrations also followed this trend.

Toxic contaminants. Heavy metals and PCBs were assessed by doing tissue analysis on mussels collected from three sites in the estuary. Results from mussel tissues and sediments collected at these stations suggest that metals and PCBs are not present in the water column in concentrations that cause measurable bioaccumulation.

Microbial Results

Several sampling stations showed notably high densities of fecal coliform bacteria throughout the survey period. Essex River samples all exceeded the criteria of 14 coliform/ml for approved shellfish areas. Tributary stations at the Castle Neck River, an unnamed tributary off Burnham Road, and Walker Creek greatly exceeded the Water Quality Standards for class SA waters every time they were sampled (SA = excellent habitat for fish, wildlife, primary/secondary contact recreation, approved areas for shellfish harvesting without depuration, and excellent aesthetic values) (Commonwealth of Massachusetts 1995). Stations in tributaries or upriver near Essex town center showed occasional or slightly elevated coliform densities. Results from these sites, “indicate possible sewage contamination from nearby septic systems that may be failing. These sites should be investigated further to pinpoint sources so that remedial action can be implemented. Stations with only slightly elevated counts were most likely influenced by upstream sources of bacterial contamination or possibly from road runoff” (DEP 1989, 1990). Open water stations in Essex Bay rarely exceed water quality standards for coliform bacteria because of high flushing rates and minimal impacts of land use activities nearby.

The town of Essex instituted a sampling program in 1995 to investigate pollutant types and sources as part of their wastewater management planning. The program includes sampling: 1) selected points in the town’s lakes, streams, rivers, and estuary, 2) storm drains, and 3) septic systems. A description of each sampling program follows (Dames and Moore 1999b).

1) In August, 1995, the town initiated a sampling program in major streams and drainage ways with significant development near Chebacco Lake, the coastline, and

marshes. Additionally, minor streams or drainage ways that were suspected of contamination were sampled. This monitoring consisted of bacteria sampling and shoreline surveys. Chebacco Lake shoreline, Alewife Brook, Essex River, Eben Creek, Soginese Creek, and Essex Bay were also visually surveyed for illegal discharges.

2) In April, 1995, the town initiated a storm drain outfall sampling program during dry and wet weather events. Samples were analyzed for fecal coliform and streptococci concentrations. In drains where fecal coliform concentrations were above 200 coliform/100 ml and the coliform to streptococci ratio was greater than 4.0, the drain was posted as being contaminated (Figure 17). Storm drains identified as contaminated are sampled quarterly while historically clean drains (fecal coliform levels less than 200 coliform/100ml) are sampled annually. *For a list of clean and contaminated storm drains, see the Town of Essex Wastewater Facilities Plan/MEPA Special Procedures Phase 1 Report.*

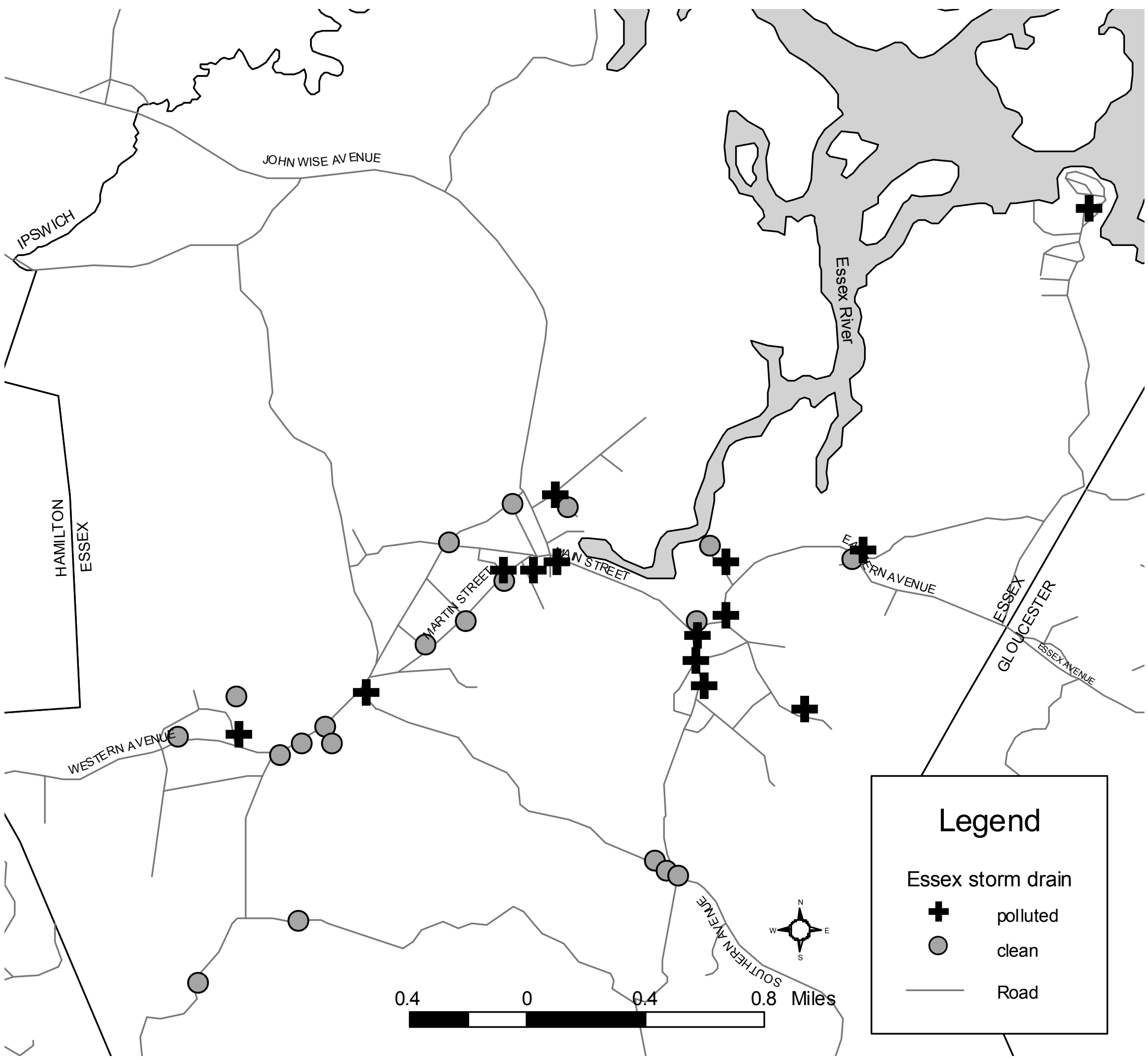

Figure 17. Essex storm drain summary (Dames and Moore 1999b)

3) In areas surrounding contaminated drains, the Board of Health dye tested homes to locate direct discharges. Of the 574 septic systems that were inspected, 292 failed a Title 5 septic system evaluation. The total number of systems that failed a soil evaluation is 160. The most common cause for septic failure is submergence of the disposal system in elevated groundwater. High groundwater and permeable soils in the upper layers provide a pathway for poorly treated wastewater to enter the storm drain system. Septic systems that were found to be directly discharging sewage were ordered to cease discharging and to upgrade their system to meet Title 5 standards. All such systems have been upgraded.

In 1998, the town of Essex also began developing a wastewater management facilities plan and the required Environmental Impact Report. In 1999, the town completed a Phase 1 report, which established the need for a centralized sewer collection system. A Phase 2 report (to be completed in 2000) will include sampling information to date (Dames and Moore 1999a). In March 2000, the Gloucester City Council agreed to allow Essex to hook up to the city's sewer system. That agreement allows Essex to construct a sewer line along Essex Avenue from the Wellspring House in Gloucester to the Essex border. The town will pay approximately $1.12 million for the right to send their wastewater to Gloucester (Mandarini 2000). River and stream monitoring will continue as part of this plan (Ferris per comm 2000).

Pollution Sources in Essex Bay

Data from these sampling programs indicate that high levels of fecal coliform (greater than 1,000 coliform/100ml) were observed in Alewife Brook (at Landing Road), Addison Brook (at Addison Street and Southern Avenue), Burnhams Court, Eben Creek (at Grove Street and Eastern Avenue), Essex River (at Apple Street), and Soginese Creek. All but the sampling locations at Eben Creek (at Grove Street), Essex River, and Soginese Creek are likely impacted from nearby failing septic systems. These other three locations drain large agricultural areas with domesticated animals and wildlife that mostly contribute to the high bacteria levels. Less elevated levels of fecal coliform (200 to 1,000 fc/100ml) were observed in Alewife Brook (at Pond Street and Apple Street), Ebens Creek (upstream of Eastern Avenue), and Coffils Hollow (at Martin Street) (Dames and Moore 1999b). For more specific data about pollution sources at these locations see the 1999 *Town of Essex Wastewater Facilities Plan/MEPA Special Procedures Report* and the 1992 DMF *Sanitary Survey Report of Essex Bay*.

Water Quality Field Notes

The following responses are individual opinions rather than a consensus reached by those interviewed. Field note information can be used by local and regional resource managers to assess research needs, guide restoration efforts, prioritize future workplans, and design technical assistance programs.

The following people were interviewed about water quality:

Robert Buchsbaum	Massachusetts Audubon Society
Wayne Castonguay	The Trustees of Reservations and Ipswich Pollution Control Committee
Chuck Hopkinson	Woods Hole Marine Biological Laboratory
Jeff Kennedy	Massachusetts Division of Marine Fisheries
Dave Roach	Massachusetts Division of Marine Fisheries

1. Based on the information gathered through existing research, has water quality improved or declined in the past 20 years? Where is this trend going in the next 20 years?

- In the past 20 years, results have varied depending on the location; Ipswich River water quality has improved by implementing the Ipswich CPCC recommendations while places in the Parker River Watershed, especially the Mill and Little Rivers, have declined. Plum Island Sound and Essex Bay water quality continues to have low to moderate levels of pollutants and consistently has better water quality than the tributaries because of higher flushing rates.
- In the next 20 years, nonpoint source pollution will continue to degrade water quality as development and land use patterns change; tributary water quality will decline as impervious surface increases, open space decreases, and impaired wetland functions reduce pollutant filtration. Also, unless recreational boating practices are better managed, leaking petroleum products, toxic metals, human waste, and resuspended sediments will further degrade estuarine water quality. However, we currently know much more about water quality pollutants and their sources than we did in the past; state agencies like DMF and CZM are committed to monitoring coastal waters. If agency actions are combined with improvements at the local level (i.e, Ipswich upgrading the wastewater treatment plant and Essex exploring sewering options), then water quality will likely improve.

2. What additional research and data is needed to improve water quality assessments?

- A more frequent, regional sampling schedule is needed to determine changing hot spots and sources of bacterial contamination in tributaries. Existing data from tributary sampling is hard to interpret since sampling is not done regularly. For example, recent DMF sampling indicates that fecal coliform concentrations in dry weather are increasing from the town landing to the mouth of the Ipswich River; more research is needed to explain these results.
- In places where monitoring consistently shows elevated pollution levels, efforts should focus on remediating pollutant sources rather than doing more monitoring. The Ipswich CPCC report is an example where hot spots have been identified and need to be remediated before more resources should be put toward monitoring.
- More research is needed on tributary nutrient loading (phosphorus and nitrogen). This monitoring will be especially important as future development and stormwater runoff increases. Data gathered from these studies will help researchers and managers prepare for and predict problems of eutrophication in ACEC coastal waters.
- More data from the Newbury landfill is needed to make an assessment of its water quality impact.

3. What are important water quality threats or issues that need to be addressed?

- Increased development in ACEC watersheds and resulting nutrient loading from lawn fertilizers, wastewater, and impervious surface runoff.
- Agricultural runoff from the upper watersheds. For example, the expansion of Tendercrop Farm and the lease of surrounding wetlands for cattle grazing is resulting in discharge of sediment, bacteria, and nutrients into the Little River.
- Nutrient and microbial inputs from failing septic systems.
- Discharge from the Newburyport industrial park into the Little River.
- Discharge levels and monitoring practices at the Governor Dummer Academy treatment plant.
- Ultimate impacts of the Essex/Gloucester sewer system solution.
- Upgrade performance of the Ipswich treatment plant.

4. What are opportunities for water quality improvement?

- Work with local officials to implement growth management bylaws and regulations related to subdivision development, stormwater management, and wetlands protection. These efforts will help reduce future nonpoint source pollution from land-based development.
- Promote the use of Best Management Practices (BMPs) to remediate sources of agricultural and stormwater runoff.
- Continue using information from DMF shoreline surveys to target water quality hot spots and promote septic system upgrades or use of BMPs.
- Remediate hot spots where monitoring consistently shows elevated pollutant levels. In addition to identified failing septic systems, specific hot spots where remediation efforts should focus include:
  - <u>Essex</u>: Contaminated storm drains (Figure 17),
  - <u>Ipswich</u>: Labor in Vain Creek, Miles Brook, and Kimball Brook all have spikes in wet weather from agricultural waste in the upper watershed,
  - <u>Parker River Watershed</u>: Little River, Mill River, and Ox Pasture Brook, which have agricultural and industrial park pollution sources as well as the Governor Dummer Academy wastewater treatment plant.
- Promote the Ipswich CPCC report and use of a planning assistant to implement water quality remediation and shellfish management recommendations as a model in other ACEC towns.